

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

Chains, Rings and Spectroscopy

Thursday

24 JANUARY 2002

Morning

1 hour 30 minutes

2814

Candidates answer on the question paper.

Additional materials:

Scientific calculator

Data Sheet for Chemistry

Candidate Name	Centre Number	Candidate Number												
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TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You are advised to show all the steps in any calculations.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	14	
2	11	
3	12	
4	17	
5	11	
6	14	
7	11	
TOTAL	90	

This question paper consists of 15 printed pages and 1 blank page.

Answer **all** the questions.

1 Benzene can be nitrated to form nitrobenzene, $\text{C}_6\text{H}_5\text{NO}_2$.

(a) Draw the structural formula for **benzene** and give its empirical formula.

structure:

empirical formula [2]

(b) State the reagents needed for the nitration of benzene.

..... [2]

(c) An electrophile is formed during the nitration of benzene.

(i) What is the formula of this electrophile?

..... [1]

(ii) Write an equation for the production of the electrophile.

..... [1]

(iii) Use curly arrows to show the mechanism for the nitration of benzene.

[4]

- (d) 10.0 g of benzene was nitrated to give 13.3 g of nitrobenzene. Calculate the percentage yield, giving your answer to three significant figures.

[4]

[Total : 14]

- 2 Amines are commonly occurring compounds. Ethylamine, $\text{C}_2\text{H}_5\text{NH}_2$, is a primary amine responsible for the smell of decaying fish.

(a) Explain the meaning of the term *primary amine*.

.....
 [1]

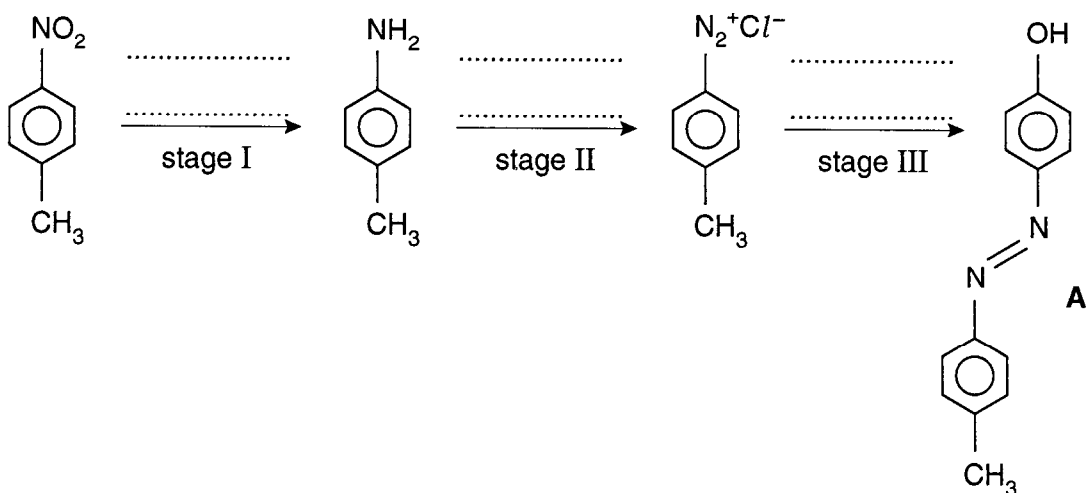
(b) Ethylamine and phenylamine are bases.

Write an equation to show ethylamine acting as a base.

..... [2]

(c) Aromatic amines such as phenylamine are intermediates in the synthesis of many other compounds such as **A** below.

(i) Complete the scheme by writing the reagents on the lines provided.



[5]

(ii) Write the equations for stages I and III.

stage I

stage III

[2]

(iii) State a general use for compounds such as **A**.

..... [1]

[Total : 11]

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Question 3 starts on page 6

- 3 (a) Esters are well known as compounds providing the flavour in many fruits and the scent of some flowers. The ester $\text{CH}_3(\text{CH}_2)_2\text{COOCH}_3$ contributes to the aroma of apples.

(i) Name the ester $\text{CH}_3(\text{CH}_2)_2\text{COOCH}_3$.

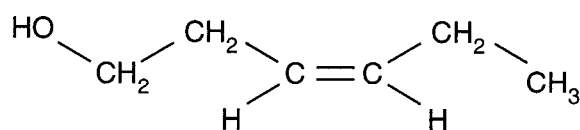
..... [1]

(ii) State the reagents and conditions for the hydrolysis of this ester in the laboratory.

.....

..... [3]

- (b) Leaf alcohol, **B**, is a stereoisomer that can form when insects eat leaves.



B

(i) Draw the skeletal formula of **B**.

[1]

(ii) Draw the geometric isomer of **B**.

[1]

- (iii) Draw a structure for the ester expected when **B** reacts with ethanoic acid in the presence of an acid catalyst. Show **all** the bonds in the ester group.

[2]

- (c) A chemist analysed a sample of **B** and determined its M_r value

- (i) Deduce the M_r value that the chemist would expect for leaf alcohol.

expected M_r [1]

- (ii) What technique could the chemist have used to determine the M_r for leaf alcohol?

..... [1]

- (iii) A chemist reacted **B** to form a product **C** with an M_r 18 units less than that of **B**.
Suggest a structure for **C** and deduce the type of reaction that took place.

structure of C

type of reaction [2]

[Total : 12]

- 4 Propene is in the 'top 20' most heavily used chemical feedstocks in the U.S.A. It is used for the manufacture of polymers such as poly(propene).

(a) Suggest, with a reason, the names of **two** other alkenes you might expect to find in the 'top 20' feedstocks.

.....

.....

.....

..... [3]

(b) Explain why there are three different stereochemical forms of poly(propene). These forms are described as atactic, isotactic and syndiotactic. Illustrate your answer with diagrams.

(In this question, 1 mark is available for the quality of written communication.)

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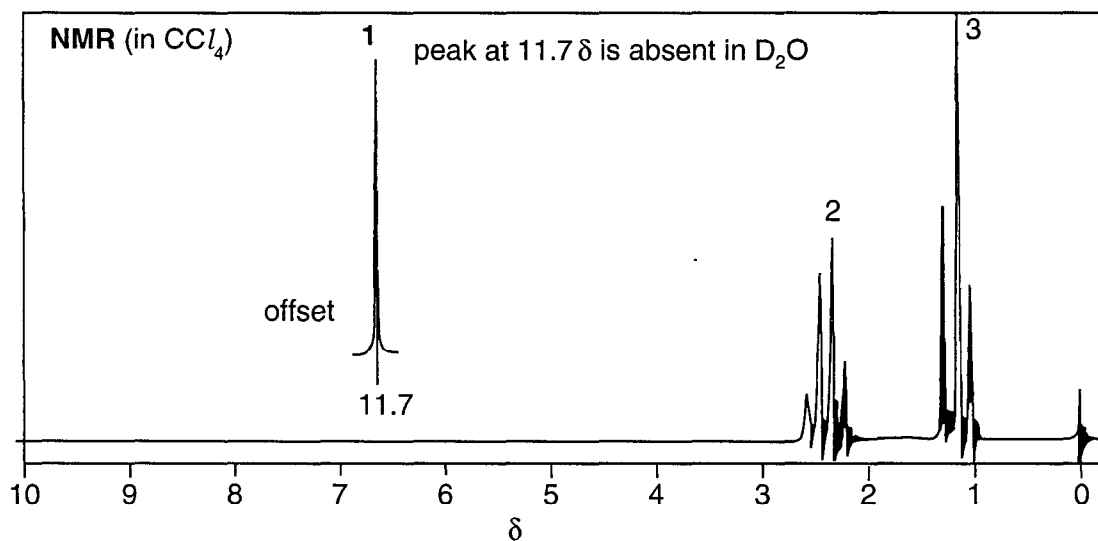
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- (c) Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, can be synthesised from propene. The nmr spectrum of propanoic acid is shown below.



- (i) Use the *Data Sheet* to explain the chemical shifts and splitting patterns shown by each peak in this nmr spectrum.

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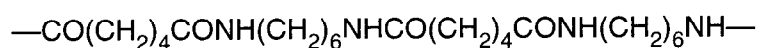
..... [6]

- (ii) Explain why the peak at 11.7δ disappears on addition of D_2O .

..... [1]

[Total : 17]

- 5 A diagram of a section of nylon-6,6 is shown below.



- (a) Identify the monomer(s) from which nylon-6,6 is obtained.

.....
 [2]

- (b) State and explain the type of polymerisation reaction which gives nylon-6,6.

.....

 [2]

- (c) Proteins and polypeptides are polymers which have been described as being similar to nylon-6,6.

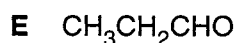
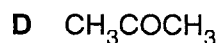
Suggest with the aid of diagrams and equations.

- **one** structural similarity
- **one** chemical similarity
- **one** important difference

(In this question, 1 mark is available for the quality of written communication.)

[Total : 11]

- 6 Like esters, carbonyl compounds can contribute to the smell of plants and food. The carbonyl compounds **D** and **E** are structural isomers.



- (a) Name compounds **D** and **E**.

(i) **D**

(ii) **E** [2]

- (b) State the reagents you would use and the observations you would make for a simple chemical test

- (i) in which **D** and **E** behave in the same way;

reagent(s)

observation [2]

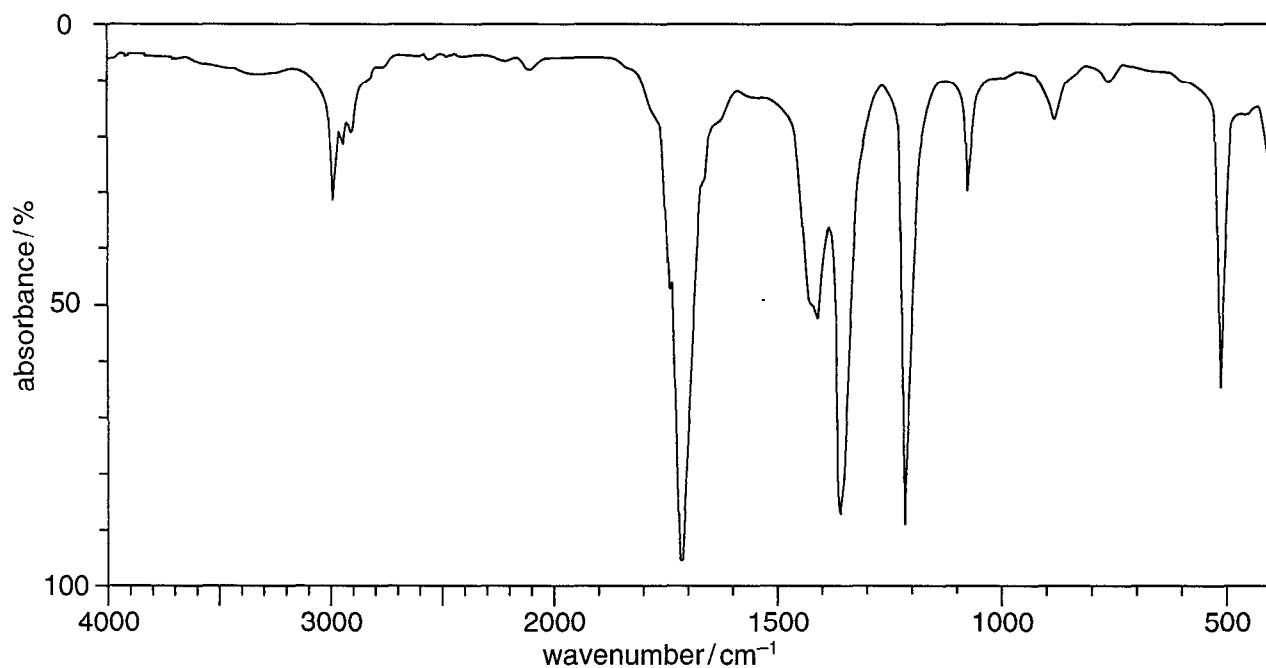
- (ii) which can be used to distinguish between **D** and **E**.

reagent(s)

observation for **D**

observation for **E** [3]

(c) The infrared spectrum of **D** is shown below.



- (i) On the spectrum above, mark with a cross the absorption peak that identifies the functional group. Explain how you made your choice. (Use the *Data Sheet* provided to answer this question.)

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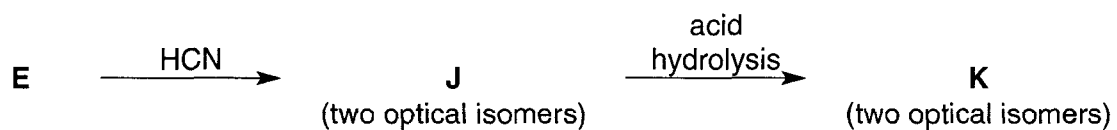
 [2]

- (ii) Reduction of compound **D** with NaBH_4 produces a compound with the molecular formula $\text{C}_3\text{H}_8\text{O}$.

How would the infrared spectrum of this product be different from that of **D**?

.....
 [2]

- (d) Compound **K** can be synthesised in two steps from compound **E**, $\text{CH}_3\text{CH}_2\text{CHO}$. The synthetic steps are shown below.



- (i) Draw the structural formula of **J**.

[1]

- (ii) Draw three-dimensional structures to show clearly the **two** optical isomers of **K**.

[2]

[Total : 14]

- 7 The α -amino acid glycine, $\text{H}_2\text{NCH}_2\text{COOH}$, is used as a poultry feed additive and in the fertiliser industry. There are twenty naturally occurring α -amino acids.

(a) Draw the general formula for an α -amino acid.

[1]

(b) In the crystalline state, glycine contains zwitterions.

(i) Draw the structure of the zwitterion of glycine.

[1]

(ii) Explain how this zwitterion arises.

.....

.....

.....

.....

..... [2]

(iii) Crystals of glycine melt between 230 and 235°C. Explain why the melting point of glycine is higher than that of hydroxyethanoic acid, HOCH_2COOH (m.p. 75–80 °C).

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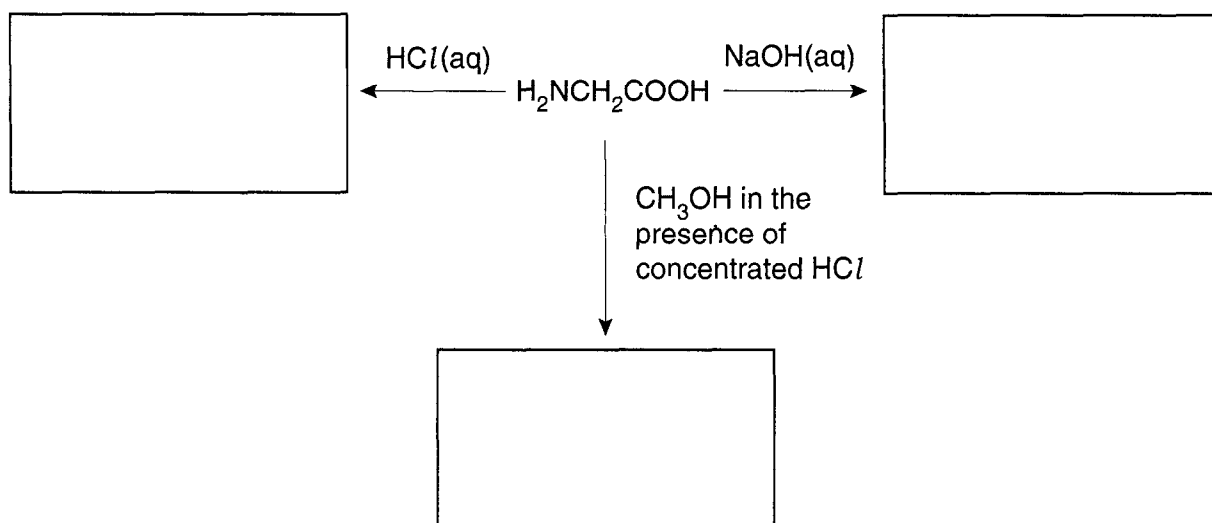
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..... [3]

- (c) In the boxes below, draw suggested structures for the organic products obtained from glycine.



[4]

[Total : 11]